

CHROMOSOME NUMBERS IN SOME NORTH AMERICAN SPECIES OF THE GENUS *CIRSIUM*¹

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As part of a comprehensive review of the systematics of *Cirsium*, the senior author, with the assistance and collaboration of the junior author, has accumulated data on chromosome number in a number of species. In this genus, it appears that chromosome data can contribute significantly to an understanding of its taxonomy. The present report records those data accumulated during the past three years and it is hoped will represent only the first in a series of reports treating this subject.

To date, chromosome numbers for eleven species of American *cirsiums* have been published, viz., *C. discolor* and *C. muticum* (Ownbey, 1951; Frankton & Moore, 1963), *C. cernuum* (*C. nivale*) and *C. subcoriaceum* (Stoutamire & Beaman, 1960), *C. flodmanii* and *C. undulatum* (Frankton & Moore, 1961), *C. horridulum* (Turner, Ellison & King, 1961), *C. edule* and *C. brevistylum* (Moore & Frankton, 1962b), *C. skutchii* (Beaman & Turner, 1962), and *C. altissimum* (Frankton & Moore, 1963). Twelve additional species are reported upon in the present paper. Counts for the total of twenty-three species are summarized in Table 1, and further details for the twelve newly reported and five previously reported species are given in the body of the text.

Chromosome numbers in sporophytic cells of American *Cirsium* species so far examined vary from eighteen to thirty-four. Evidently, the gametic number of chromosomes forms a continuous series from nine to seventeen. One or two extra chromosomes have been observed in somatic cells of several species. The data indicate that all American species of *Cirsium* are diploids, although Frankton & Moore (1963) report a possible instance of triploidy in *C. muticum*. Chromosome numbers for a large number of Eurasian and

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Japanese species of *Cirsium* have been recorded. In all of these species the base or x number equals 17. All of the Eurasian species except two are diploids and these are tetraploids. In Japan, however, triploid, tetraploid, and hexaploid species have been reported by Aishima (1934) and Arano (1957). For a recent tabulation of chromosome numbers in Eurasian *Cynareae* the reader should refer to Moore & Frankton (1962a).

It has been suggested by Frankton & Moore (1961) that many American species of *Cirsium* may have arisen through the same process of reduction in chromosome number known to have occurred in other Compositae. In brief, this is accomplished by successive translocations from a chromosome to non-homologous chromosomes. When a centric segment has lost all genetic material essential to the viability of the race, the centric itself may be lost through meiotic accident without detriment to the survival of the race. The present writers see nothing inconsistent with this hypothesis in the data presented here and in fact the situation in the series *Undulata*, for which data are more nearly complete, affords abundant support for the hypothesis.

Morphology of the individual chromosomes of *Cirsium* species leaves much to be desired if this is to contribute substantially to the taxonomy of the genus. Due to the small size of the chromosomes, it is very difficult to pinpoint the location of the centromere on all or even a majority of the chromosomes of a given cell, even in good preparations. In gross size, the chromosomes in all species we have examined form a closely graded series from smallest to largest. One pair of satellite chromosomes probably is present in all species examined and one or two additional satellite chromosomes were clearly visible in some preparations. In all cases the satellite was part of a medium or large-sized chromosome.

A useful method of making chromosomal comparisons between closely related species of *Cirsium* has been adopted by Frankton & Moore (l.c.). By carefully measuring the length of each chromosome of a diploid cell at metaphase, a total length of chromosomes for the cell can be established. In

practice, several cells are studied and an average figure calculated. This figure can be compared with that of other related species and certain probable relationships inferred.

Nomenclature of the subgeneric taxa above the species level adopted here follows exactly that of Petrak (1917). In this paper he treated a majority of the species which occur north of the Mexican border. The species found in Mexico and Central America were treated by the same author in earlier papers (Petrak, 1910, 1911).

Petrak placed all of the American species of *Cirsium* in the subgenus *Eucirsium*. The subgenus for North America is divided into six sections. A very large majority of our species are assigned to a single section, the *Onotrophe*. The section *Onotrophe* is taxonomically complex. It is divided into eleven subsections, many of which are further broken down into named assemblages of species which presumably represent series. In Table 1 and elsewhere through the paper, twenty-one species of the *Onotrophe* are mentioned. Chromosome counts have also been made on one species of the section *Cirsiopsis* and on one species of the section *Erythrolaena* as shown in the table. The remaining three sections of North American cirsiums are not mentioned in this paper. It is not our intent here to evaluate Petrak's subgeneric classification of *Cirsium*, nor would it be possible to do so without more exhaustive knowledge of the genus. For the present Petrak's system provides a useful and, undoubtedly to a high degree, accurate framework upon which to base further studies of the genus.

In the accompanying Table 1, it has been necessary to interpolate a few species which were unknown to Petrak or not fully treated by him. The species include *C. brevistylum*, *C. foliosum*, *C. hillii*, certain *Undulata* and *C. skutchii*.

METHODS

Almost all of our counts have been made from root-tip squashes. Seeds are scarified by chipping off part of the pericarp from the distal end and side, then laid on moist filter paper in covered petri dishes. The embryos begin to imbibe water immediately and within 24 hours the pericarp

can be removed and discarded. The embryo is then placed in another sterile dish, allowed to grow for another 24 hours and then sterilized for three minutes in dilute potassium permanganate solution. It is then washed in distilled water and grown under sterile conditions as above for 4-7 days. Valuable seedlings may be lost if the cultures are allowed to become contaminated with fungi. When the primary root is of sufficient length (ca. 15 mm.) the tip is excised and placed immediately in .0025 mol./liter aqueous oxyquinoline solution where it remains for 3-4 hours. It is then transferred to Warmke's solution for 4-5 minutes and preserved in Carnoy's solution No. 2. Root tip squashes stained with acetocarmine are prepared according to standard procedures. We have made most of our preparations permanent.

The effect of pretreating with oxyquinoline is to cause maximum contraction of the chromosomes at metaphase and this makes for easier and more accurate counting. In our materials, however, a certain amount of morphological detail is lost in the maximally contracted chromosomes and this has some disadvantages for karyotypic analysis. Furthermore, as a consequence of unusual shortening of the chromosomes, it will be found that the measurements of length dimension are somewhat less than are reported by other workers.

Removal of the tip of the primary root for cytological purposes in no way injures the seedlings. They are permitted to remain in the sterile dishes until the cotyledons turn green and the branch rootlets appear well started. They are then planted in sand-filled flats and fed with a balanced aqueous nutrient solution. The plants can be transferred to a regular soil mix in individual pots or flats when they begin to show vigorous growth. If proper records are maintained, it is possible to grow the seedlings from which chromosome data has been obtained to maturity and to collect voucher specimens from them. In practice, we have often grown seedlings only to a stage sufficient to establish their specific identity for certain so as to eliminate undetected human errors in handling the materials.

All of the species examined in the course of these studies belong to the section *Onotrophe*.

Subsection STENANTHA:

Cirsium mexicanum DC. $n = 10$; $2n = 22$.

MEXICO. CHIAPAS: About 1 mile east of Teopisca, along Route No. 190, *R. M. King, No. 2855* (MIN). $2n = 22$. OAXACA: About 8 miles northwest of Nochistlán, along Route No. 190, *R. M. King, No. 3532* (MIN, TEX). $n = 10$. Count made by B. L. Turner, W. L. Ellison and R. M. King, in 1960 and published by permission of Dr. Turner. TAMAULIPAS: Rancho del Cielo, 5 miles northwest of Gómez Fariás, alt. 3300 ft., *B. E. Harrell, No. 258* (MIN). $2n = 22$.

One and probably two pairs of chromosomes with satellites were observed in *No. 2855*. If our understanding of this species is correct, it is the most common and widespread *Cirsium* in Mexico. Superficially it appears to be a member of the *C. undulatum* alliance, but the presence of crisped hispidity in varying degrees on the upper leaf surfaces mitigates against its placement there. Petrak (1917) placed it in another subsection, the *Stenantha*, of the *Onotrophe*.

An inconsistency exists between the chromosome number communicated to the senior author by Dr. Turner and our own observations on other collections identified as the same species. Possibly this variation in number actually exists.

Subsection ACAULIA:

Cirsium drummondii T. & G. $2n = 34$.

CANADA. MANITOBA: Riding Mountain National Park, about 5.5 miles north of Wasagaming, Highway No. 10, *G. B. Ownbey, No. 2879* (MIN).

SOUTH DAKOTA. Pennington Co.: 4.6 miles south of Hill City, *G. B. & F. Ownbey, No. 2861*. (*C. coccinatum* Osterh.) (MIN).

Two pairs of chromosomes with satellites were observed with some certainty in the South Dakota material. Only one pair was observed in the Canadian material, but another pair could easily have been obscured in the preparation.

C. drummondii has been confused with *C. foliosum* (Hook.) DC. by one of the present writers (GBO) and others in the past, but we are now convinced that the two are fully distinct although closely related species. The presence of *C. drummondii* in the Black Hills of South Dakota represents an important disjunction from its primary Canadian range. Plants collected from the two localities cited above are, however, morphologically indistinguishable. The Black Hills plant was described as *Cirsium coccinatum* by George

E. Osterhout in 1934. Evidently, Osterhout was unfamiliar with *C. drummondii*, but at the same time recognized the distinctness of the Black Hills specimens from the omnipresent *C. foliosum* of the western mountainous areas.

***Cirsium foliosum* (Hook.) DC. $2n = 34, 36?$**

COLORADO. JACKSON Co.: 1.3 miles north of Walden, G. B. and F. Ownbey, No. 1497 (MIN). $2n = 34$. LA PLATA Co.: 21.9 miles east of Durango, U. S. Highway No. 160, alt. ca. 7200 ft., G. B. Ownbey & Y. Hsi, No. 2642 (MIN). $2n = 34, 36?$ MONTANA. POWELL Co.: 5 miles southwest of Avon, U. S. Highway No. 12, alt. ca. 4800 ft., G. B. Ownbey & Y. Hsi, No. 2908 (MIN). $2n = 34, 36?$

One pair of chromosomes with satellites was observed in most cells at mitotic metaphase. This variable, wide-ranging species is in need of extensive cytotaxonomic analysis.

No. 2908 is the segregate species described as *Carduus kelseyi* Rydb.

Subsection ODORATA: Series PUMILA:

***Cirsium hillii* (Canby) Fern. $2n = 30$.**

MINNESOTA. HENNEPIN Co.: Near Veteran's Hospital, Fort Snelling, G. B. Ownbey, No. 2857. (MIN).

One pair of chromosomes with satellites was observed.

C. hillii is perennial by means of root and crown sprouts and this has been and still remains the most useful way to distinguish it from its closest relative, *C. pumilum* (Nutt.) Spreng., a biennial.

***Cirsium pumilum* (Nutt.) Spreng. $2n = 30$.**

CONNECTICUT. NEW HAVEN Co.: Vicinity of New Haven, J. R. Reeder, s.n.

No chromosomal peculiarities were observed. Plants were grown in the garden from seeds provided by Dr. Reeder.

Subsect. ACANTHOPHYLLA: Series MUTICA:

***Cirsium muticum* Michx. $2n = 20$.**

MINNESOTA. HENNEPIN Co.: 5 miles southwest of Edina, U. S. Highway No. 212, G. B. Ownbey & Y. Hsi, No. 2859.

No chromosomes with satellites were observed in our preparations. They are, however, almost certainly present.

Frankton & Moore (1963) have recently reported somatic numbers of 20, 22, 30 and 31, in *C. muticum*. The two higher

counts were obtained from materials originating in Florida. Earlier somatic counts by Ownbey (1951) and the number reported here have not deviated from the regular number of 20 for the species as it occurs in north-central United States. Further chromosome studies of this wide-ranging plant should prove of great interest.

Series ALTISSIMA:

Cirsium altissimum (L.) Spreng. $2n = 18, 20$.

IOWA. BOONE Co.: 3 miles east of Boone, G. B. Ownbey, No. 2863 (MIN). $2n = 18, 20$. WISCONSIN. BARRON Co.: About 9 miles east of Cameron, 0.4 mile west of Rusk-Barron Co. line, U. S. Highway No. 8, G. B. & F. Ownbey, No. 2855 in part (MIN). $2n = 18$.

One pair of chromosomes definitely had satellites, and there was a suggestion of a second pair which could not be confirmed. The fully contracted chromosomes measured 0.8 to 1.5 microns in length.

No. 2855 consisted of a mixed population of *C. altissimum* and *C. discolor* together with many putative hybrids. The counts were from seedlings of a "pure" *C. altissimum* plant.

No. 2863 was the segregate called *C. iowense* (Pammel) Fern. in some manuals. We consider *C. iowense* to be either synonymous with *C. altissimum* or a hybrid derivative of that species and *C. discolor*. The type locality of *Cnicus iowensis* Pammel is the Ledges, a short distance south of Boone. In 1959 one of us (GBO) visited the Ledges and searched carefully but without success for Pammel's segregate but found only typical *C. discolor*. However, numerous plants of undoubted *C. iowense*, i.e., *C. altissimum* in the broad sense, were found along a railroad embankment east of Boone. A few viable seeds were obtained. Because of the lateness of the season it was impossible to form any opinion about the fertility of the naturally occurring plants. Four plants grown from seeds, however, proved to be fully fertile.

The cytology of *C. altissimum* has been examined recently by Frankton & Moore (1963). No deviation from a somatic number of 18 was found in the two collections studied.

Cirsium discolor (Muhl.) Spreng. $2n = 20$.

WISCONSIN. BARRON Co.: About 9 miles east of Cameron, 0.4

miles west of Rusk-Barron Co. line, U. S. Highway No. 8, *G. B. & F. Ownbey*, No. 2855 in part (MIN).

Growing with *C. altissimum* and numerous putative hybrids. The counts were made from seedlings of a "pure" *C. discolor* plant. At least one and possibly two pairs of chromosomes with satellites were observed. Length of the fully contracted chromosomes varied from 1.0-1.7 microns.

An extra chromosome was reported in one seedling of *C. discolor* by Frankton & Moore (1963). Counts by the present authors and by the senior author in a previous report (1951) have not deviated from 20.

Series UNDULATA:

***Cirsium brevifolium* Nutt. $2n = 22$.**

IDAHO. LATAH Co.: Moscow, *G. B. Ownbey*, No. 2661 (MIN).

One and possibly two pairs of chromosomes with satellites were observed. Length of the fully contracted chromosomes varies from 1.0-1.5 microns.

***Cirsium canescens* Nutt. $2n = 34$, (36).**

COLORADO. JACKSON Co.: 1.3 miles north of Walden, *G. B. & F. Ownbey*, No. 1496 (MIN). $2n = 34$. NEBRASKA. CHERRY Co.: 18.6 miles southwest of Merriam, *G. B. Ownbey & Y. Hsi*, No. 2601 (MIN). $2n = 34$. SOUTH DAKOTA. BUTTE Co.: 17.0 miles northeast of Newell, U. S. Highway No. 212, *G. B. Ownbey & Y. Hsi*, No. 2507 (MIN). $2n = 34$. SOUTH DAKOTA. FALL RIVER Co.: 9.0 miles north of Delrichs, S. Dak. Highway No. 79, *G. B. Ownbey & Y. Hsi*, No. 2600. $2n = 34$. WYOMING. ALBANY Co.: 0.8 mile northwest of Centennial, alt. 8100 ft., *G. B. & F. Ownbey*, No. 1307 (MIN). $2n = 34$. WYOMING. ALBANY Co.: Veedavoo Glen, ca. 20 miles southeast of Laramie, a short distance east of U. S. Highway No. 30, *G. B. Ownbey & Y. Hsi*, No. 2611 (MIN). $2n = 34$ (3 plants), 36 (1 plant).

At least one and probably two pairs of chromosomes with satellites are present in this species. Fully contracted chromosomes measured from 0.5-1.2 microns in length. Two extra chromosomes were observed in one plant of No. 2611. Other less reliable figures not recorded here indicate an unusual degree of instability in the normal diploid number for this species. Possibly this is due to unbalanced genomes resultant from hybridization with other species, an hypothesis for which we have considerable observational evidence.

The characteristic monocarpic form of this species native to the sand hill areas of Nebraska has been accorded species rank as *Cirsium plattense* (Rydb.) Cock. ex Daniels by some authors. This robust form intergrades imperceptibly to the west and north with a more branched and sometimes longer-lived form with smaller heads. It is to this latter phase of the species that Nuttall's type specimen belongs.

Plants of No. 2611 collected in the wild were not typical of the species and genetic contamination from some other species was suspected. No. 1496 came from a mixed population of *C. canescens* and *C. foliosum* (Hook.) DC. and putative hybrids of these two.

Cirsium canescens Nutt. $\times$ *C. foliosum* (Hook.) DC. $2n = 34$.

COLORADO. JACKSON Co.: 1.3 miles north of Walden, G. B. & F. Ownbey, No. 1497a (MIN).

The count was made from a seedling grown from seed of a putative natural hybrid.

Cirsium flodmanii (Rydb.) Arthur $n = 11$; $2n = 22$ (24).

NEBRASKA. DIXON Co.: 14.1 miles east of Laurel, U. S. Highway No. 20, G. B. Ownbey & Y. Hsi, No. 2487 (MIN). $n = 11$; $2n = 22$. NORTH DAKOTA. WILLIAMS Co.: 7 miles east of Ray, M. Ownbey, No. 3228 (MIN). $2n = 22, 24$. WYOMING. CROOK Co.: 6 miles west of Alladin, M. Ownbey, No. 3215 (MIN). $2n = 22$.

One and probably two pairs of chromosomes of this species bear satellites. Length of the fully contracted chromosomes of No. 2487 varied from 0.8-1.4 microns. The presence of two extra chromosomes in one plant of No. 3288 was fully verified. Haploid counts of No. 2487 were made from PMC squashes. Only one satellite-bearing chromosome was visible in this preparation.

Frankton & Moore (1961) report a maximum number of four satellite chromosomes in *C. flodmanii*. They found no variation from the somatic number of 22 chromosomes in a large number of collections from southwestern Canada and Montana.

Cirsium ochrocentrum Gray $2n = 32$ (30, 31, 32)

ARIZONA. COCONINO Co.: 16.7 miles south of Grand Canyon City, Ariz. Highway No. 64, G. B. & F. Ownbey, No. 1822 (MIN). $2n = 30, 31, 32$. YAVAPAI Co.: 3.8 miles east of Seligman, M. & G. B. Ownbey, No. 3001 (MIN). $2n = 32$. COLORADO. MONTROSE Co.: 7.1 miles south of Montrose, U. S. Highway No. 550, alt. ca. 6200 ft., G. B.

Ownbey & Y. Hsi, No. 2635 (MIN). 2n = 32. SOUTH DAKOTA. FALL RIVER Co.: 14.3 miles north of Ardmore, G. B. Ownbey & Y. Hsi, No. 2504 (MIN). 2n = 32.

One and almost certainly two pairs of chromosomes with satellites are present in this species. Fully contracted chromosomes in *No. 2504* were found to vary from 0.5-1.0 micron in length. Of the four collections studied, only *No. 1822* showed any plant to plant variation from the usual 16 pairs of chromosomes characteristic of this species.

Collection numbers *2504* and *2635* represent the typical phase of this species ranging from the Great Plains westward to Wyoming, eastern Utah and New Mexico. This phase normally has strongly decurrent leaves and pale reddish-lavender corollas. Numbers *1822* and *3001* represent the phase found in Arizona southward and eastward to New Mexico, Sonora and Chihuahua. These plants have less strongly decurrent leaves with often broad and semi-clasping bases and bright scarlet-red corollas. Further study may indicate that the latter plants should be recognized nomenclatorially as a distinct subspecies or species but for the present we are leaving them with the typical form.

***Cirsium pitcheri* (Torr.) T. & G. 2n = 34.**

WISCONSIN. DOOR Co.: near White Fish Bay (northeast of Sturgeon Bay), *G. B. Ownbey & Y. Hsi, No. 2655 (MIN).*

One pair of chromosomes with satellites was observed. Maximally contracted chromosomes varied from 0.5-1.2 microns in length. *C. pitcheri* is one of the comparatively few flowering plant species having a Great Lakes distributional pattern. It is fully distinct from, but in its vegetative morphology similar to, *C. canescens* Nutt. They appear to have similar ecological requirements to the extent that *C. pitcheri* is confined to the areas of partially stabilized sand back of the shore lines whereas over much of its range *C. canescens* is a characteristic component of the Sand Hills flora. Both the Sand Hills *C. canescens* and *C. pitcheri* are monocarpic. We think that *C. pitcheri* may be a derived species and its very narrow ecological spectrum and morphological homogeneity may indicate an advanced stage of depletion of its genetic variability.

Cirsium subniveum Rydb. $2n = 32$.

UTAH. UTAH Co.: 22.4 miles southeast of Thistle, U. S. Highway No. 6-50, alt. ca. 7000 ft., *G. B. Ownbey & Y. Hsi*, No. 2660 (MIN).

One pair of chromosomes with satellites was observed. Maximally contracted chromosomes measured 0.5-1.2 microns in length. Although we have compared our collection with the type of *C. subniveum* and the similarity between the two is close, there is still a small residuum of doubt as to the correct identification of our specimens. We place *C. subniveum* in the series *Undulata* of the subsect. *Acanthophylla* with hesitation. Its closer affinities may lie elsewhere.

Cirsium tracyi (Rydb.) Petrak $2n = 24$.

COLORADO. DELTA Co.: 1.8 miles southeast of Paonia, *G. B. Ownbey & Y. Hsi*, No. 2631 (MIN). (*Carduus acutatus* Osterh.) EAGLE Co.: Wolcott, alt. ca. 7000 ft., *G. B. Ownbey & E. Hsi*, No. 2623 (MIN). (*Carduus floccosus* Rydb.) MONTEZUMA Co.: 2 miles northwest of Pleasant View, alt. ca. 6800 ft., *G. B. Ownbey & Y. Hsi*, No. 2647 (MIN). MONTROSE Co.: Cimarron, alt. ca. 7000 ft., *G. B. Ownbey & Y. Hsi*, No. 2633 (MIN). UTAH. SAN JUAN Co.: Elk Mountain road (Elk Ridge), 2.0 miles north of its junction with the Natural Bridge National Monument road west of Blanding, alt. ca. 8400 ft., *G. B. Ownbey & Y. Hsi*, No. 2657 (MIN).

One pair of chromosomes with satellites was observed. The maximally contracted chromosomes measured from 0.8-2.4 microns long. The type locality of *Carduus acutatus* Osterhout is Paonia, the point of origin for our No. 2631. Comparison of the types establishes this species as a synonym of *C. tracyi*. Similarly, the type locality of *Carduus floccosus* Rydb. is Wolcott, the source of our No. 2623, and a comparison of the type of *C. floccosus* with that of *C. tracyi* convinces us that they are synonymous. A search was made for specimens of *C. tracyi* at the type locality, Mancos, Colorado, but none was found there. We collected the species at its nearest occurrence to the westward, near Pleasant View, Colorado, our No. 2647. A study of the chromosomes of these three collections and two additional ones revealed no data inconsistent with combining the several proposed species under a single binomial, which in accordance with the International Rules must be *Cirsium tracyi* (Rydb.) Petrak.

Cirsium undulatum (Nutt.) Spreng. $n = 13$; $2n = 26$.

MONTANA. LAKE Co.: 4.5 miles northwest of Polson, U. S. Highway No. 93, *G. B. Ownbey & Y. Hsi, No. 2900* (MIN). MINERAL Co.: 7.6 miles west of Alberton, U. S. Highway No. 10, alt. ca. 3000 ft., *G. B. & F. Ownbey, No. 2663* (MIN). NEBRASKA. BOX BUTTE Co.: 21.8 miles south of Crawford, Nebr. Highway No. 2, *G. B. Ownbey & Y. Hsi, No. 2503* (MIN). SHERIDAN Co.: 10.9 miles east of Alliance, Nebr. Highway No. 2, *G. B. Ownbey & Y. Hsi, No. 2499* (MIN). SOUTH DAKOTA. CUSTER Co.: 14.3 miles south of Custer, U. S. Highway No. A85, *G. B. & F. Ownbey, No. 1297* (MIN). WASHINGTON. ADAMS Co.: 16 miles east of Washtucna, Wash. Highway No. 118, *G. B. & F. Ownbey, No. 2662* (MIN). $n = 13$; $2n = 26$. WYOMING. CROOK Co.: 0.5 mile east of summit of Bearlodge Mountains, on road between Alva, Wyo. and Belle Fourche, S. Dak., *G. B. Ownbey & Y. Hsi, No. 2917* (MIN). CROOK Co.: 7 miles northwest of Hulett, *M. Ownbey, No. 3213* (MIN).

One pair of chromosomes with satellites was seen in nearly every preparation. When fully contracted the chromosomes measured from 0.7-1.5 microns in length.

Frankton & Moore (1961) report a maximum of four satellite chromosomes in *C. undulatum*. A constant number of 26 chromosomes was found in a large number of collections from southwestern Canada and from Montana, South Dakota and Idaho in the United States.

This species is the most common and widespread *Cirsium* in western United States. It is found in the Great Plains from southern Canada to northern Mexico and westward across the mountains to the Pacific Northwest. Some variation in the species from region to region can be detected and it was thought that some variation in chromosome number or morphology might also occur. The species has, however, proved to be surprisingly constant to date, but more studies are indicated.

Cirsium wheeleri (Gray) Petrak $2n = 28$.

ARIZONA. NAVAJO Co.: 0.2 mile southeast of Showlow, *G. B. & F. Ownbey, No. 1806* (MIN).

At least one pair and possibly two pairs of chromosomes bear satellites. The fully contracted chromosomes measured from 0.5-1.2 microns in length.

DISCUSSION

It is probably premature to make any sweeping general-

izations about the chromosomal situation in American *cirsiums*. It has been, however, of some interest to bring together all of the literature reports available to us at this time and to combine them in tabular form with those presented for the first time in this paper. Of the twenty-three species listed in Table 1, several have been examined repeatedly from widely separated parts of their ranges. The need for subjecting all of the wide ranging species to this form of analysis should be emphasized.

In contrast to the stability in chromosome numbers of Old World species of *Cirsium*, exclusive of the polyploid series in Japan, the American species exhibit an astonishing prevalence of reduction in numbers. As previously noted, diploid numbers at all levels of 18 through 34 have been found in one or more species. This fact will inevitably weigh heavily in the future development of any hypothetical phyletic sequences within groups of related species. We find in the series *Undulata* an excellent example of a reduction series that may find its counterpart in other alliances of related species within the genus. If we hypothesize that in the *Undulata* the more primitive species from the standpoint of chromosome numbers are those with 34 somatic chromosomes, then the other species in the series are derived. It does not follow, however, that the 34-chromosome species, namely, *C. canescens* and *C. pitcheri* are, in a morphological or physiological sense, necessarily more primitive than the other members of their group. The junior author has examined the correlations of chromosome numbers and morphological features of the *Undulata* to some extent (Hsi, mss., 1960). It is expected that a revised version of these observations will appear in a separate report, however, and they will not be detailed here. Probably changes in chromosome number are no more than a secondary pathway by which genetic diversity and subsequent morphological diversity can be achieved. Such changes are significant, particularly if numerous simple and reciprocal translocations of small chromosome segments are involved, in providing genetic recombinations not attainable by any other means. These rearrangements comprise a part, although probably

not the most important part in any case, of the raw materials upon which selection operates. In the case of American *cirsiums*, chromosomal rearrangements concomitant with reduction in numbers may have played an unusually important role in speciation.

SUMMARY

Chromosome counts for seventeen species of American *cirsiums* are reported. Twelve of these species are recorded for the first time; five species for which published records exist are verified. American species examined by all authors to date total twenty-three. All species so far examined appear to be diploids and all possible genomes from nine through seventeen occur in at least one species. One or two extra chromosomes are sometimes found in individual plants. One or two pairs of satellite chromosomes were observed by the present authors in almost all species examined and it is suspected that they are universally present in the American species of the genus. A trend toward reduction of chromosome numbers in related groups of species is noted, the series *Undulata* being the best documented example of this trend. Chromosome morphology by itself has not provided any criteria of taxonomic value in distinguishing species or species groups to the present writers, but the work of others indicates that total length of the somatic chromosomes at metaphase, i.e., the sum of the lengths of the individual chromosomes, may ultimately provide useful comparative data.

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Table I. Summary of Counts of North American *Cirsium* Species.

Nomenclature	Author	Gameto- phytic	Sporo- phytic
Subgenus EUCIRSIUM			
Sect. CIRSIOPSIS			
<i>C. nivale</i> (Kunth)	Stoutamire & Beaman	17	
Schz.-Bip.	(1960)		
(<i>C. cernuum</i> Lag.)			
Sect. ONOTROPHE			
Subsect. MINUTIFLORA			
<i>C. brevistylum</i> Cronq.	Moore & Frankton		34
	(1962)		
<i>C. edule</i> Nutt.	Moore & Frankton		34
	(1962)		
Subsect. STENANTHA			
Series MEXICANA			
<i>C. mexicanum</i> DC.	Ownbey & Hsi		22
	Turner, Ellison & King	10	
Subsect. ACAULIA			
<i>C. drummondii</i> T. & G.	Ownbey & Hsi		34

<i>C. foliosum</i> (Hook.) DC.	Ownbey & Hsi		34 (36?)
<i>C. skutchii</i> Blake	Beaman & Turner (1962)	17	
Subsect. ODORATA			
Series PUMILA			
<i>C. hillii</i> (Canby) Fern.	Ownbey & Hsi		30
<i>C. pumilum</i> (Nutt.) Spreng.	Ownbey & Hsi		30
Series HORRIDULA			
<i>C. horridulum</i> Michx.	Turner, Ellison & King (1961)	16	
Subsect. ACANTHOPHYLLA			
Series MUTICA			
<i>C. muticum</i> Michx.	Ownbey (1951); Frankton & Moore (1963)		20 20, 22, 30, 31
	Ownbey & Hsi		20
Series ALTISSIMA			
<i>C. altissimum</i> (L.) Spreng.	Frankton & Moore (1963)		18
	Ownbey & Hsi		18, 20
<i>C. discolor</i> (Muhl.) Spreng.	Ownbey (1951) Frankton & Moore (1963)		20 20, 21
	Ownbey & Hsi		20
Series UNDULATA			
<i>C. brevifolium</i> Nutt.	Ownbey & Hsi		22
<i>C. canescens</i> Nutt.	Ownbey & Hsi		34, 36
<i>C. flodmanii</i> (Rydb.) Arthur	Frankton & Moore (1961)		22
	Ownbey & Hsi	11	22, 24
<i>C. ochrocentrum</i> Gray	Ownbey & Hsi		32, 30, 31
<i>C. pitcheri</i> (Torr.) T. & G.	Ownbey & Hsi		34
<i>C. subniveum</i> Rydb.	Ownbey & Hsi		32
<i>C. tracyi</i> (Rydb.) Petrak	Ownbey & Hsi		24
<i>C. undulatum</i> (Nutt.) Spreng.	Frankton & Moore (1961)		26
	Ownbey & Hsi	13	26
<i>C. wheeleri</i> (Gray) Petrak	Ownbey & Hsi		28
Sect. ERYTHROLAENA			
Subsect. CONSPICUA			
<i>C. subcoriaceum</i> (Less.) Schz.-Bip.	Stoutamire & Beaman (1960)	17	